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SPECIFICATION

1. Title of the Invention

Method of producing a semiconductor circuit

2. Claims

1. A method of producing a semiconductor circuit, characterized in that a first substrate, on which a circuit is formed through a first film or a first film and at least one layer of a second film, is bonded to a second substrate on a circuit formation side thereof, and then the first film is removed by etching to transfer the circuit onto the second substrate.

3. Detailed Description of the Invention

[Field of the Industrial Application]

The present invention relates to a method of producing a semiconductor circuit, and more particularly to a method of producing a semiconductor circuit without limiting a substrate material.

[Prior Art]

Research and development of flat type display devices (displays) which are represented by liquid crystal displays (LCD), are a thin type, and have low consumption power have been made actively. For those displays, a substrate on which wirings are formed or an active matrix substrate on which active elements (amorphous Si thin film transistors [a-Si TFTs] or polycrystalline Si thin film transistors [poly-Si TFTs]) are formed in order to obtain a high display quality is required, and glass is generally used as a

material of a substrate on which a wiring or an active matrix is formed. However, there is a limitation to a heat resistant temperature in glass. Thus, a large limitation is placed on the formation of the wirings or the active elements. In other words, a heat resistant temperature of inexpensive glass is generally low and it cannot be prevented to contain alkali metal by which the active elements are adversely affected. Therefore, the development of an inexpensive glass substrate in which a contained impurity is small and a heat resistant temperature is high is required. However, the desired development of glass satisfying these requirements cannot be made. On the other hand, when the glass substrate is used, there is a problem in that a display cannot be folded small when the display is not used because of the rigidity thereof. Thus, the advent of a display using a flexible substrate which can be folded small when the display is not used is desired.

As a technique of eliminating the limitations of the substrate, a device transfer technique has been reported in International Electron Device Meeting (IEDM) in 1989 (K. Sumiyoshi, et al., "DEVICE LAYER TRANSFERRED POLY-SI TFT ARRAY FOR HIGH RESOLUTION LIQUID CRYSTAL PROJECTOR", IEDM89, p.165, 1989).

[Problems to be solved by the Invention]

The above-mentioned technique relates to the one in which an active matrix is manufactured on an Si substrate through an oxide film (SiO_2 film) and the substrate is then bonded to another substrate, and after that, the Si substrate is removed by a polishing process. In the polishing process, because a polishing rate of SiO_2 is smaller that that of Si, polishing can be stopped at a time when SiO_2 appears. As a result, a device formed on the Si substrate can be transferred onto another substrate. According to the above-mentioned report, the same process is used twice. The device is first transferred to another Si substrate and next transferred to a glass substrate. This is because it is prevented to invert the device, and it is not essential. In this method, an Si substrate having a high heat resistant temperature can be used as the substrate on which the active matrix is manufactured. Thus, there is an advantage that a limitation related to a manufacturing temperature in manufacturing the active matrix is small and a high performance TFT can be manufactured at a high temperature. However, because transfer is conducted using polishing, when the device is transferred to a flexible substrate having

no rigidity, there is an essential problem in that the Si substrate is deformed as the substrate becomes thinner by polishing, so that polishing cannot be uniformly conducted. Further, there is a problem in that a polishing machine with a high cost must be prepared.

An object of the present invention is to solve the above-mentioned problems and to provide a method of transferring a circuit without having a limitation to a substrate.

[Means for solving the Problem]

According to the present invention, a method of removing a film interposed between a circuit formed on a substrate and the substrate by etching is used. If an etching rate to the film is large and the film can be selectively removed with respect to the manufactured circuit, a device, and the substrate, the circuit and the device can be transferred.

Therefore, a method of producing a semiconductor circuit according to the present invention is characterized in that a first substrate, on which a circuit is formed through a first film or a first film and at least one layer of a second film, is bonded to a second substrate on a circuit formation side thereof, and then the first film is removed by etching to transfer the circuit onto the second substrate.

[Operation]

According to the present invention, a substrate having a high heat resistant temperature or a substrate which does not contain any substance by which a circuit is adversely affected can be used as a substrate on which a circuit is formed, so that limitations to the substrate can be reduced. In addition, when a circuit is transferred, polishing as in the prior is not required to be conducted. Thus, a polishing machine with a high cost is unnecessary. Even when the circuit is transferred to a flexible substrate having no rigidity, there is no problem in that the substrate is deformed.

[Embodiment]

Embodiment 1

Figs. 1(a) to 1(f) are step cross sectional views of a first embodiment of a method of producing a semiconductor circuit according to the present invention. In this

embodiment, there is shown an example in which an active matrix is formed as a circuit on a first substrate of Si having a diameter of, for example, 4 inches and the circuit is transferred onto a second substrate of polyethylene telephthalate (PET).

First, as shown in Fig. 1(a), a molybdenum film having a thickness of about 1 μm is deposited as a first film 12 on a first substrate 11 of Si. Next, as shown in (b), in order not to expose the molybdenum film 12 to an oxidizing atmosphere during the manufacturing process, an SiO_2 film is deposited as a second film 13, and then a TFT 17 using a-Si, a pixel electrode 18 of ITO (indium tin oxide), and a wiring of Al are formed by a general active matrix manufacturing method to manufacture an active matrix 14. Next, for example, an epoxy base adhesive 5 is applied onto the active matrix 14 as shown in (c), and a PET film as a second substrate 16 is bonded onto the circuit as shown in (d). After that, the substrate is immersed into a hydrogen peroxide solution to etch the molybdenum film 12 as shown in (e). At this time, an etching solution is heated in order to increase an etching rate. Thus, etching is progressed to completely remove the molybdenum film 12. Finally, when the first substrate 11 is completely separated as shown in (f), a semiconductor is completed.

Here, with respect to the reason why molybdenum is used for the first film 12, the molybdenum is weak to an oxidizing atmosphere, can be easily etching-removed by being immersed into a hydrogen peroxide solution, and has an extremely high selective etching property because the hydrogen peroxide solution does not etch materials used for manufacturing the active matrix, such as Si, SiO_2, Al, and ITO at all. In addition, the reason why the second film 13 is provided is because the molybdenum film 12 is not directly exposed to an oxidizing atmosphere in manufacturing the active matrix.

After that, this substrate (second substrate 16) and a counter substrate made of PET on which a counter electrode is formed are bonded to each other through a polymer dispersed liquid crystal sandwiched therebetween to complete a display. When this display is displayed, it is confirmed that display properties equivalent to those formed on a glass substrate are obtained. In addition, it is found that this display has a flexible property and can resist bending. Thus, a display which can be folded small when the display is not used can be realized.

Embodiment 2

Instead of the molybdenum film 12 in Embodiment 1, a molybdenum film obtained by sputtering using a gas containing oxygen when the molybdenum film is formed is used. Thus, the molybdenum film contains oxygen at a high concentration. The molybdenum film containing oxygen at a high concentration has a larger etching rate than that of a molybdenum film with respect to a hydrogen peroxide solution. Processes after that are the same as in Embodiment 1. As a result, there is an effect in which the removal of the molybdenum film in Fig. 1(e) is made at an extremely high rate. Properties and the like are completely the same.

Embodiment 3

As the first film 12 in Embodiment 1, a CaF_2 (calcium fluoride) film is used instead of the molybdenum film. This material can be epitaxial-grown on a single crystalline Si substrate. In addition, an Si can be epitaxial-grown on the CaF_2. In this embodiment, the epitaxial-grown Si film is used as an active layer of a TFT and an active matrix is manufactured. The active matrix is bonded to a PET film as a second substrate, and CaF_2 is removed using diluted fluoric acid. CaF_2 can be easily etched with diluted fluoric acid. Thus, the active matrix can be transferred to the second substrate as in Embodiments 1 and 2. In this embodiment, the second film 13 (SiO_2 film) is not formed. Processes after that are the same as in Embodiment 1 and a display is manufactured. As a result, it is confirmed that display properties are obtained.

Embodiment 4

Fig. 2(a) shows a fourth embodiment of the present invention and Fig. 2(b) is a part enlarged cross sectional view in Fig. 2(a). According to the method described in Embodiment 1, a large number of Si substrates are used as first substrates 41, an active matrix is manufactured on each substrate, and the substrates 41 are bonded onto a second substrate 42 of PET as shown in Fig. 2(a). After that, the active matrixes are transferred onto the second substrate 42 as in Embodiment 1. After that, as shown in Fig. 2(b), through holes 43 are formed by a photo process, and then a metallic film is deposited and a metal wiring 44 connecting among the respective active matrixes is formed by a photo

process. As a result, a large area active matrix in which the respective active matrixes are connected can be completed.

After that, this substrate (second substrate 42) and a counter substrate made of PET on which a counter electrode is formed are bonded to each other through a polymer dispersed liquid crystal sandwiched therebetween to complete a display. When this display is displayed, it is confirmed that display properties are obtained.

Because the through holes 43 and the wiring 44 are formed at low temperatures, they can be formed even on a substrate such as the PET substrate (42) with a low heat resistant temperature without causing a problem. In addition, the formation of the wiring is possible even by screen-printing.

As described above-mentioned, when the circuits are separately formed and transferred onto the large area substrate, a large scale circuit can be easily produced on the large area substrate. In this case, the separated circuits can be screened by an individual test before the circuits are bonded to the large area substrate and only good items can be transferred thereto. Thus, the manufacturing yield of the large scale circuit can be improved.

Embodiment 5

Fig. 3 shows a fifth embodiment of the present invention. According to the same method as described in Embodiment 1, Si substrates are used as first substrates 51, driver circuits 53 for an active matrix each of which are composed of a shift resistor are formed thereon using poly-Si TFTs, and the substrates 51 are bonded to a second substrate 52 of glass on which an active matrix 54 using a-Si TFTs is formed as shown in Fig. 3. Next, the driver circuits are transferred to the second substrate 52 as in Embodiment 1. After that, the driver circuits 53 and the active matrix are connected with one another by the same method as in Embodiment 4. When circuit operation is tested, it is confirmed that signals from the driver circuits are transferred to the active matrix 54. As in Embodiment, a display is completed and display operation can be confirmed.

Embodiment 6

Fig. 4 shows a sixth embodiment of the present invention. According to the same

method as described in Embodiment 1, Si substrates are used as first substrates, an n-channel TFT 61 made of poly-Si is formed on the Si substrate, and similarly a p-channel TFT 62 is formed on another Si substrate. The substrates are transferred to a second substrate 63 of glass as shown in Fig. 4 and connected with each other to compose a complementary MOS (CMOS) circuit by the method in Embodiment 4. When this circuit is tested, CMOS operation can be confirmed.

Thus, when the CMOS circuit in which a process is complicated when the circuit is manufactured according to a series of steps is divided into an n-channel portion and a p-channel portion and the portions are formed and transferred to compose the circuit, the process can be simplified.

As described above-mentioned, according to the above-mentioned respective embodiments, a circuit having a high heat resistant temperature or a substrate which does not contain any substance by which the circuit is adversely affected can be used as a substrate on which a circuit is formed, so that limitations to the substrate can be reduced. In addition, when a circuit is transferred, polishing as in the prior art is not required to be conducted. Thus, a polishing machine with a high cost is unnecessary and a cost reduction can be achieved. Even when the circuit is transferred to a flexible substrate having no rigidity, there is no problem in that the substrate is deformed.

The spirit of the present invention is that a first film which can be easily removed by etching is formed on a first substrate, a circuit is formed thereon, then the substrate is bonded to a second substrate, and then the first film is removed to transfer the circuit onto the second substrate. The second film is to prevent the first film from being damaged in manufacturing the circuit. Thus, it is needless to say that various modifications can be made without departing from the spirit of the present invention. In the above-mentioned embodiments, for example, the a-Si TFT, the poly-Si TFT, the active matrix using the epitaxial-grown Si film, and the driver circuit are indicated for the circuit. However, the circuit may be a circuit such as a data buffer circuit. As the second film, an SiN_x film or the like can be used in addition to the SiO_2 film. The adhesive is preferably selected according to a use and it is apparent that there is no limitation.

[Effects of the Invention]

As described above-mentioned, according to the present invention, the circuit can be transferred without using an expensive polishing machine, so that a cost reduction can be achieved. In addition, since the circuits are separately formed and transferred onto the large area substrate, a large scale circuit can be easily produced. At this time, the separated circuits can be screened by an individual test and only good items can be transferred thereto. Thus, the manufacturing yield of the large scale circuit can be improved. Further, when the CMOS circuit in which a process is complicated when the circuit is manufactured according to a series of steps is divided into an n-channel portion and a p-channel portion and the portions are formed and transferred to compose the circuit, the process can be simplified.

4. Brief Description of the Drawings

Figs. 1(a) to 1(f) are step cross sectional views of a first embodiment of a method of producing a semiconductor circuit according to the present invention, Fig. 2(a) shows a fourth embodiment of the present invention, Fig. 2(b) is a part enlarged cross sectional view in Fig. 2(a), Fig. 3 shows a fifth embodiment of the present invention, and Fig. 4 shows a sixth embodiment of the present invention.

11, 41, 51, 62: first substrate
12: first film
13: second film
14: active matrix
15: adhesive
16, 42, 52, 63: second substrate
61: n-channel TFT
62: p-channel TFT

FIG. 1

11: FIRST SUBSTRATE

12: FIRST FILM

13: SECOND FILM

14: ACTIVE MATRIX

15: BOND

16: SECOND SUBSTRATE

17: TFT

18: PIXEL ELECTRODE

FIG. 2

41: FIRST SUBSTRATE

42: SECOND SUBSTARTE

43: THROUGH HOLE

44: METAL WIRING

FIG. 3

51: FIRST SUBSTRATE

52: SECOND SUBSTRATE

53: DRIVER CIRCUIT

54: ACTIVE MATRIX

FIG. 4

61: N-CHANNEL TFT

62: P-CHANNEL TFT

63: SECOND SUBSTRATE